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Advancements and Challenges in Agriculture: A Comprehensive Review of Machine Learning and IoT Applications in Vertical Farming and Controlled Environment Agriculture

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Abstract

Farming is not easy to approach things, as we must feed approximately 8 million people daily. Traditional farming is an old-fashioned technique that takes so much time to produce. Due to this, we need some modern technology to increase our production. But research has shown that in 50 years, there will be 8.3 billion more people on Earth than there are now. It will need an extra 109 hectares of cropland, which doesn't already exist, to feed these new immigrants. There are also clear signs that pollution and the rise in population are worsening. Despite the benefits of smart traditional farming, there are a number of drawbacks to traditional farming. Regardless of soil pollution, water pollution, land pollution, energy loss, climatic conditions, electricity waste, and transportation costs, another option will be better for the food production industry. According to the research, to feed 8 billion people, we would need an additional 109 hectares of land. That is the typical problem that the farmers will face because most of the hollandaise nowadays. So, using this building concept, we will implement indoor farming, which means planting fruits and vegetables inside the tall building, an advanced form of a greenhouse. The innovative idea, also known as Vertical Farming (VF), integrates agricultural design with building design in a tall structure inside of cities. Implementing VF will solve many challenges by utilizing modern machine learning, IoT, and AI techniques, increasing VF productivity and quality. In VF, aeroponics consumes 98% less water than conventional farming. Human health, comfort, and productivity directly correlate with the indoor climate. Systems for vertical plant walls with sensors and actuators have become a good way to control the environment inside a building. They are using a set-up of vertical plant walls with anomaly detection techniques based on machine learning to increase automation and intelligence for predictive indoor climate maintenance.

Keywords: Drawbacks of traditional farming, Vertical farming, Sensors and actuators, Anomaly detection, Predictive indoor climate maintenance.

1 | Introduction

Coming closer to a brand-new technology will cause new essential demands and new outcomes. Switching to a new manner of contemporary thinking will enhance our imaginative and prescient vision of the arena. The entire world, the whole universe, will no longer have limitations by way of revolutionary thoughts;

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additionally, it will provoke non-public conceptual thoughts. The agriculture sector is the backbone of a rural financial system, and it happens to contribute 19.9% of GDP in 2020-21. By 2050, the arena's population is projected to be nearly nine billion, with most of the population, or 70%, remaining in urban areas [1]. This overview paper aims to determine the analytics of statistical overview of the rising era merge with new contemporary-day farming. It has been reviewed from approximately 15-20 study papers on how conceptual and logical thoughts are the best way to deal with populace problems, pollutants, climatic imbalance, meal security, loss of knowledge, biofuels, etc. According to estimates, we need more than 800 hectares of farmland to meet the demand for food. This indicates that just 10% of agricultural land is now available for cultivation, and a yield explosion is anticipated to provide 90% of the advantages related to food [2]. Because of the huge quantity of living beings, we want the manufacturing of common meals to boom at approximately 50% of the present-day rate [3]. This implies that we should choose trustworthy, value-friendly, and enjoyable actions. Agriculture is the primary source of income in developing agricultural countries, where 82% of farmers are underprivileged and 70% live in rural areas. As a result, these countries face severe challenges, and agriculture is becoming less critical due to urbanization [4].

However, not only can land shortage problems change the entire system, but there are also a lot of other kinds of pollutants, like soil, water, air, etc. Soil pollutants, erosion, and a variety of other soil-related issues all pose challenges to plant development. Soil pollutants influence meal safety by lowering crop yields and being first-rate. Safe, nutritious, and appropriate first-rate meals can best be produced if our soils are healthful. Without healthy soils, we may be unable to produce meals. Another kind of pollutant is well-known, and it's called water pollutants. Water pollution is caused by a variety of factors, including commercial factories, pest management products, animal medicines, slurry, sewage sludge, and manure. We all know that 71% of the water in our world's climate is fresh water, with lakes, rivers, and other bodies of water accounting for the other 2.75%. About 70% of freshwater is used for agriculture, 18% for industry, and 12% for household needs. Aquaculture water that has undergone the nitrification process can provide the vitamins required for plant life [4]. Due to pollutants and, most glaringly, due to the populace, the imbalance of weather results in worldwide warming.

On the other hand, heavy floods and excessive temperatures ruin plants and veggies, and the value of the entirety will increase. Therefore, pollutants influence human health, animals' health, and surroundings, in addition to culmination and veggies. So, to cope with those demanding situations, take a look at approximately 20–30 study papers from 2017–2022 that have synthesized the street map closer to the sensing of the era and have been found with the use of the brand new era like gadget mastering, IOT, synthetic intelligence, deep mastering, cloud computing, etc. we can handle the problem of water pollutant and as well as various types of contaminants can be not good but dangerous to our health. These gadgets not only help to reduce the problems, but it has been noticed that the conventional method for photograph-type duties has been primarily based totally on hand- engineered functions, a Haar-like function extraction approach, and machine mechanically extracting functions from the supplied pictures. Viola-Jones's set of rules has created deep gadget mastering, etc. Now, in conventional farming, each sing and sensor node is linked to an unmarried antenna. It's been found that the customers each send and get hold of the actual time statistics via sensor node and track the bring about day-by-day agenda within the utility or cell phones. The author took into consideration Wi-Fi Sensor Networks (WSN) and installed a clever estimation for soil parameters [5].

So, ultimately, we ought to manipulate the land area to fulfill the general public's wishes. It has been expected that if we satisfy the meal call, the starvation index may go as high as 811 million people—approximately 10% of the arena's populace — who frequently visit mattresses hungry. The struggle in Ukraine affected the scenario worse in 2022, as struggles confined worldwide meal supplies, boosting prices. So essentially, we ought to minimize land area and boom our manufacturing. One such fashion that is understood in our agricultural quarter is the new contemporary era, which is primarily the solution to all kinds of issues.

To some extent, Vertical Farming (VF) may be the solution that can accomplish those meal needs. VF is an entirely new contemporary-day kind of era that mixes the layout of homes and farms all collectively in an

excessive-upward thrust structure. The use of water in VF has decreased to 70%-90% [6]. VF has its synonyms, and they're called greenhouses, indoor farming, etc. There are so many algorithms that might be crossed while reading about VF, and a number of them are the evolutionary set of rules, the genetic set of rules, mutation, health evaluation [1], etc. There are many upper-hand of VF, which might be renewable strength, changing energy, and the advantage of grey water [7]–[9]. It has been observed that plant life that has grown with the assistance of hydroponics develops quicker compared to other methods in a shorter duration of time. The idea behind the hydroponics approach is to supply plant life and veggies without soil and small areas. There are strategies for growing this in horizontal and vertical hydroponics [10]. Similar to how we domesticate plants and vegetables, we will domesticate fish farms inside the vertical farm. Aquaponics is a waste-reduction method that also serves as a supplier of plant nutrition.

But now, the question arises of how the implementation will take place and the way the era will merge with VF.

Implementation of any era with new contemporary-day strategies wishes human intelligence, human-gadget intelligence, logical enforcement, the right setup, and the maximum essential element is algorithms to execute. Authors have mentioned that if we merge gadget mastery with VF, then there may be enhancements to farming. Authors say that anomalies are detected and what takes place while alarms may be mechanically activated and redirected to administrators [11]. It has investigated the overall performance of each prediction primarily based on its total and sample reputation, primarily total anomaly detection. Machine mastering allows the procedure to extract summary facts from good-sized statistics amassed from indoor weather. Additionally, the initial wave of models assessed within the test uses linear regression to address concerns about supervised learning. Linear regression is the initial wave of models assessed within the test to address supervised learning difficulties [11]–[13]. Apart from this, there are numerous kinds of fashions like neural networks, synthetic neural communities ANN, auto encoders, recurrent neural communities, LSTM-encoder-decoder, etc. There are many sets of rules in gadget mastering; however, the most well-known ones as far as gadget mastering are the Bayesian community and synthetic neural community. The authors additionally mentioned approximately the drawback of the Bayesian community and ANN set of rules that couldn't produce suitable movement and manage movement primarily based totally on parameters educated for the hydroponics machine [14].

DNN performed with outstanding accuracy within the increased plant life. No human involvement inside the machine [14]–[16]. It has been rectified that low-give-up area computing gadgets are appropriate applicants for putting automated vertical farm control into effect at a minimum rate [17].

Until now, it's been mentioned that during this paper, we've noticed functions of the recent contemporary-day era that minimize land area, much less devour of water, beneficial season, reuse of water, minimize pollutants, surroundings pleasant and the maximum essential element is much less area and greater manufacturing. In classical farming, the farmer is dependent on many outside elements, including risky climate conditions, pest disease, infrastructure deficiency, low rainfall, floods, etc., so in this situation, the writer discovered that classical farming has much less gain than VF [18]. But then again, if we look at appearance after value, conventional farming is presently more economically aggressive than VF. Food production in cities was seen as a link between the city and the people who lived there. In live performance, it contributes to food safety, eradicates poverty, improves linguistic harmony, and boosts mental health [19].

2 | Methodology

From the study of 23-30 papers from the year 2017-2022, it has been recorded that the actual structure of the study is that the agro-economy needs really some innovative ideas that can solve the problem of agriculture and food scarcity. After so many reviews, we got to know about the Job-shop Scheduling Problem (JSP), i.e., a kind of farming activity performed remotely to enhance food productivity. A framework made up of 26 groupings of sub-topics collected from several articles was created to analyze the material more thoroughly. Now, the actual problem faced by the farmers does not come from existing systems and, unfortunately, fails

to bring certain new implementations to the present situation [1]. Easy methods that were not only in the farming field but also applied in home environments and were easy to use of either artificial photosynthesis or cloud computing technology were the in-mind consideration only. Now, not only was planting crops the initiative, but looking ahead toward the crops was the main focus of the farmers, and that's why another method was used. The illness has been identified using an image recognition technique so that all pictures of spotted vegetables and fruits are detectable.

The method used to create the dot mat file is the training Image Labeller software. Data used for machine learning is kept in the cloud. Further research revealed that the picture labeler app forecasts the health of a given plant using a machine learning system, demonstrating that farmers may use this in their fields of agriculture. A simple linear regression approach and HTTPS at the application level were used as the methodology [5]. An equally successful picture augmentation procedure is essential for the development of an image classifier. Despite the fact that training samples in datasets may be vast, this may not be enough to create an effective model. Several augmentation techniques are employed, including 1) rotation (to rotate a training picture across different angles randomly), 2) intensity (helps the model adapt to variations in lighting while feeding images of varying brightness during training). To produce cropped or magnified portions of the image, use the 3) shear (change the shearing angle), 4) zoom range, and 5) vertical and vertical flip (helps the model adapt to vertically and horizontally flipped images) [20].

We can see the lettuce crop identification and the photographs in the dataset being divided into lettuce images of excellent quality and those of terrible quality by studying research papers and review articles. There are now four different divisions of disease-detection images: healthy lettuce, bacterial, fungal, and viral. If any interrupt was detected, it was immediately sent to the supervisor of this system. With the help of AI technology, we can determine or analyze the detection so that if any mis-occurrence is identified, it can be examined [9], [19], [21]. In order to do this, we use the concept of an ultrasonic sensor that gauges a plant's early stage depending on its height. In addition to illness, plant height is an observable component. In the system, we used ultrasonic sensors to determine the height of the plant. These sensors are located precisely above the plant's head. With the aid of an ultrasonic sensor, it is possible to think about heating and cooling a structure based on its location in relation to the vertical farm so that it can get the right amount of light energy. Distribution and transfer systems must be practical and adequate to facilitate the use of renewable energy [22].

A system is used in VF to successfully move and traverse over both horizontal and vertical planes, guaranteeing access to all plant positions—which is currently not a feasible approach for the average farmer to examine up to the plant's maximum height for disease detection. The proposed VF robotic navigation system includes linear bearing rods for both the x- and y-axes. The robot can effectively chart its path by estimating the distance between the camera and the plants using two cameras. A third camera is also used to identify and locate healthier plants, allowing the farmer to inspect and monitor them closely. In a VF context, this integrated system offers precise plant movement, monitoring, and care [16].

Fig. 1. Robotic arms[1].

There are some suggestions to be made regarding the use of solar energy facilities, heat pumps, and geothermal energy for both heating and cooling, as well as the potential use of groundwater, given that the entire world is currently experiencing a shortage of pure water due to pollution, drainage, and household use. Three strategies for

Dehumidification

I. The commonly used techniques of dehumidification of greenhouses are forced ventilation (using fans) and natural ventilation. In a greenhouse, ventilation may assist in replacing warm or highly humid air with cooler, drier air.

II. For example, aqueous calcium and lithium chloride solutions are employed as a desiccant in the hygroscopic technique to remove moisture from the air. This approach has the potential to be very effective, especially when combined with air temperature conditioning for a study that has to collect data via the component in research that includes scientific procedures required for acquiring information from specific testing.

III. Condensation, one of the three dehumidification techniques, is thought to be the most appropriate for indoor crop cultivation. Clear glass functions as a passive dehumidifier in normal greenhouses, while insulating materials were developed to avoid condensation on surfaces exposed to lower temperatures. Utilizing cold-surface application techniques that rely on conventional temperature control systems is expensive. Utilizing various cold sources, including geothermal, lakes, wells, basement aquifers, and water tanks, might be advantageous, especially in hot weather [8].

Now, after considering water-related problems and rectifying their solutions, and after dealing with them, we consider our next important factor in the agriculture field, i.e., soil. Until and unless soil quality is good, crops will not grow properly. For that, there are many factors in the soil, such as soil water-holding capacity, soil texture, soil moisture, etc. From the listed factors, we have chosen soil moisture that we can determine and analyze for healthier plant growth. For that, we look at soil moisture sensors positioned 5.5 centimeters below the surface of the earth. After reading the research report, it is evident that we require a hardware setup consisting of a motor, an oxygen tank, and a motor attached to the bottom of the construction. The oxygen tank supplies oxygen to the fish tank via an internal connection. The experiment was run for a continuous 15 days under the management of IoT sensor units, and the original data produced by all the sensors throughout the processing time was stored in the cloud. Then, it will be used for analytics, and judgments will be made in accordance with these outcomes [22]. The air quality can also be determined, as well as how it has affected the soil. To get the best growth, it is crucial to keep an eye on and control the level of carbon dioxide because it has a big effect on how fast plants grow. Typically, greenhouse systems have low CO2 levels. Circulation is now essential, as well as the use of available light and air during the day [22], [23]. The motive behind this experiment was to determine how much moisture from soil to plant is reaching properly. Numerous studies have shown that the internal SM-sensor interface relies on the specific sensors used to measure soil moisture, which has also produced superior results.

However, soil moisture determination is not sufficient to determine whether crops are getting sufficient nutrition from the soil or not. We also have to determine whether the crop is getting infected or not or the plant is infected with disease or not. Otherwise, the whole hard work of the farmer will get wasted. Now,

[1] www.agritecture.com

speaking in words is obviously easier than executing in practice. Farmers can't check each and every crop, vegetable, and fruit to see whether it is infected or not. So, our next focus was checking whether a disease had been caught by crops or not, and that's why we came to know about the crop disease detection system. Both software and hardware make up the crop disease detection system, with the software serving as the training data repository. The following job is to gather input data from diverse sources, compare input data to training data, and analyze potential future illness detection [24].

Now, to create artificial light, various sensors and actuators were implanted, along with moisture and minerals; this was not a human-based manual technique since, for an accurate result, i.e., from plant beds to connection in the network, all the processes needed to be done on a cloud-based remote server. Now, all these processes cannot be done manually by the farmers alone due to many factors. In addition, if we supply artificial light inside a four-cornered room for the duration of exposure, the intensity of the light also plays a crucial role. Hence, an efficient, high-intensity light source is required to maintain stable illumination. Artificial light was produced using a variety of digital hardware lighting devices, such as LED lights, and sunlight intensity was measured using an LDR or Light Dependent Resistor [15]. Now that we've finished these steps, our next goal was to track the growth of the plants. In order to achieve this, we installed a CMOS camera image sensor module inside the chamber to monitor the various development phases. Complementary Metal Oxide Semiconductor (CMOS) is sometimes referred to as an electronic eye [20] as shown in *Figs. 2 and 3*.

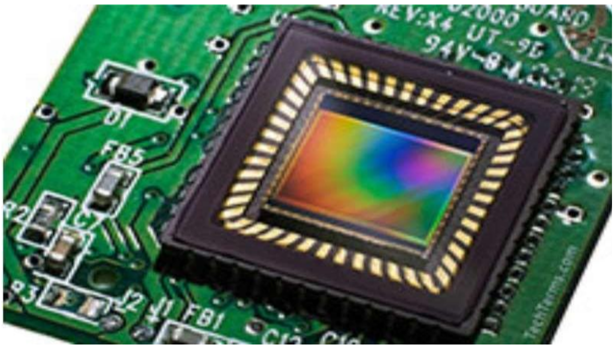

Fig. 2. Complementary metal oxide semiconductor[1].

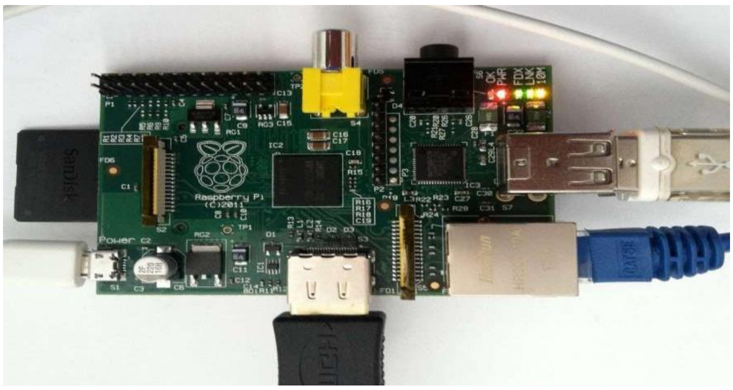

Fig. 3. Top view of CMOS in raspberry pi model with connected peripherals.

Now, to maintain all these systems that include AI, learning, and the cloud, we obviously need a proper data storage hard drive, and such kind of hard drive is there, i.e., the local server powered by Raspberry Pi helps to gather information from numerous sensors.

[1] https://techterms.com/definition/cmos

The administrators are now in charge of making sure that a thorough web of trend interlinkages has been formed and that the process results have been analyzed using an unimodal network analysis tool like NodeXL [24]. In order to account for causation, trends were regarded as vertices and linked via directed edges. According to a published report, the cumulative total temperature is important for the initial establishment of grasslands in many nations. The following were the long-term averages of the cumulative effective temperatures on the harvest dates [25]. Due to the way that trends are laid out, they often reappear among the patterns that are explained by increasing the intensity of the relationship. The setup procedure will be carried out after analysis and investigation. After this process' successful completion, it was determined that the majority of the reported VGs used 42% soil-based and 38% hydroponic plant culture technologies. Only 15% and 6% of research, respectively, employed aeroponics and aquaponics. Evidently, neither soil-based nor hydroponic garden structures are the preferred ones for using VGs [26]. Now, taking some samples of crops like 65% of timothy and 35% of meadow fescue seed, which has approximately 25 kg/ha sowing rate. The final decision will be based on the availability of top-notch fertilizers, water, and soil.

The nitrogen application amounts of -120 and 145 kg/ha resulted in a thick turf by the middle of June, and this had an impact on the development of the stand. The sword was dispersed and weak, especially on the first swing. Finally, it was observed that the result was more favorable to Timothy [25], [27]. The next target was the network analysis strategy in small towns and how the wireless approach can be reached. After much consideration and investigation, it was chosen to link a wireless internal WI-FI network that connects the SM, Controller, DMs, and UI. Now that the farmers will have preferential access, various wireless access points and a variety of Wi-Fi will be needed. But rather than that, with no external hosting costs and relief from a third party, it enables the autonomous disconnected operation [18]. Now, to implement this considerable setup, it has been recorded that the internet world will bring into broad areas of communication for low complexity sensors. According to research, the thread-based sensor can be connected to an edge computing network so that we can put the way of method for bidirectional communication [28].

Apart from that, there are many challenges regarding VF that have been determined, for which we want to maximize the integration of current technologies, such as an automated HVAC environment utilizing IoT and machine learning. This system will monitor and regulate environmental variables in real-time, allowing for optimal plant development while lowering energy use. It will also allow for remote monitoring and decision-making, resulting in increased sustainability and productivity [29].

Table 1. Recorded details about hydroponics farming per cycle cost.

Hydrophonics Farming Per Cycle Cost	
Requirments	**Cost**
Electricity	15000 INR/month
Seeds	20000 INR/month
Fertilizers	20000 INR/month
Labor	10000 INR/month
Maintenance	5000 INR/month
Packing and transportation	10000 INR/month
Per cycle cost	80000 INR

Table 2. Hydroponic farming profit in India[1].

Hydrophonics Farming Profit in India	
One-Time Yield	
Total production	3200 kg
Waste	1000 kg
Total left	2200 kg
Value in market	350 INR/kg
Value of yield	770000 INR
Profit margin in India ==	Total earning per cycle- per cycle investment 770000-80000=690000 INR/cycle

The cost of hydroponic farming per square foot amounts to 400 INR, based on a total expenditure of 20 lakh INR for a 5 thousand-square foot area that includes both one-time and continuing expenses, 400 INR as a one-time investment per square foot. Each cycle costs 16 INR, which is the investment for one square foot. Farming hydroponically makes money per square foot. 6,90,000 INR is the total profit margin on a 5000-square-foot space. 138 INR per cycle is the profit margin per square foot.

Now, some techniques have been reviewed from the study of different research papers and accumulated knowledge on how we can apply them in this field.

Neural networks

A neural network is a sort of Artificial Intelligence (AI) model that is inspired by the structure and operation of the human brain. It is made up of interconnecting nodes called neurons that are grouped into layers. These neurons collaborate to analyze and learn from input, allowing the network to spot patterns, anticipate outcomes, and accomplish complicated tasks. A neural network may increase its performance and react to new information by altering the connections between neurons via a process known as training, making it a valuable tool for diverse machine learning applications. ANN tries to solve complicated problems more precisely, like summarising papers or recognizing faces. Compared to non-explainable AIs, explainable AIs frequently perform less accurately, require less data, and mature considerably more quickly. Neural networks are the recommended solution for an automated greenhouse because of their excellent accuracy. The purpose is to provide a civilian with a computerized greenhouse, so AI is not technically required to explain its forecasts or judgments in a greenhouse [30].

CNN

CNN is an abbreviation for Convolutional Neural Network, which is a sort of artificial neural network built for image and visual data processing. It is very good at detecting patterns and characteristics in photos. CNNs develop hierarchical representations of input data using a unique design that incorporates convolutional layers, pooling layers, and fully connected layers.

Convolutional layers extract features from input images by applying filters (also known as kernels). These filters look for specific patterns, such as edges, corners, or textures. The spatial dimensions of the feature maps are then reduced by pooling layers, maintaining the most critical information while minimizing computing complexity. Finally, fully connected layers use the learned information to anticipate things like object categorization or picture segmentation.

CNNs have become a crucial technique for different computer vision tasks such as picture identification, object detection, face recognition, and many other applications linked to visual data processing due to their capacity to learn and find patterns in visual data.

In 2012, AlexNet achieved first place in the ImageNet ILSRVC [31].

[1] https://www.thefarminghouse.com/2021/08/hydroponic- farming-setup-cost.html

The top-5 error rate on the network was 15.3% while surpassing the second-place finisher by greater than 10.8% [32].

Eight layers make up AlexNet, comprising three ultimately linked levels and five convolutive layers. The first, second, and fifth convolutional layers are employed, and then three max-pooling layers.

ZFNet was introduced by Zeiler and Fergus [33]. It was a revolutionary way to understand how each layer of neural network is performing.

In order to reach this precision, NFNet modified AlexNet. The performance of each layer of AlexNetwas actually shown ZFNet, along with the parameters that might be adjusted for improved accuracy [21].

CNNs are the architecture of VGG. VGG is an image recognition CNN. It is well-known for its straightforward and consistent design, which consists of several 3x3 convolutional layers followed by max-pooling. Despite being more complex, it has served as a foundation for many recent CNN designs.

ResNet

Residual Network (ResNet) is a 2015 deep CNN design. It employs residual blocks with shortcut connections to allow the training of profound networks, thereby addressing the vanishing gradients issue. This method enabled ResNet to achieve cutting-edge performance in a variety of computer vision applications, including picture classification and object recognition [34].

LeNet-5

One of the first CNNs, LeNet-5, aided in the advancement of deep learning. LeCun et al. [35] created it in 1998 to identify handwritten digits on scanned 32x32 pixel greyscale input pictures of checks. It was used for the handwritten digit recognition task with the MNIST dataset [36].

GoogLeNet/Inception

In the 2014 ILSVRC competition, Google's GoogLeNet (also known as Inception V1) took first place. 6.67% top-5 mistake rate [37]. The challenge's organizers were now compelled to judge this performance because it was remarkably human-like. Acquiring more accuracy than Google's Neural Network proved tough and necessitated the use of human skills. With the help of Andrej Karpathy, the top-5 error rate in a single model was lowered to 5.1% and then improved to 3.6% after a few days of training [38]. The CNN used by the network was based on LeNet, but it also included an innovative component known as an "inception module."

R-CNN

One of the first notable and influential uses of CNN dealt with the issues of object segmentation, placement, detection, and segmentation. This method was put to the test on benchmark datasets, producing results that were state-of-the-art at the time on the 200-class ILSVRC-2013 object detection dataset and the VOC-2012 dataset [39].

Region proposal network

An entirely convolutional network called a Region Proposal Network (RPN) predicts object limits and objectless scores for each place at the same time. The RPN, developed by Faster R- CNN, uses a tiny network to recommend regions. RPN has a classifier that provides the region's probability. Additionally, it features a regressor that yields the bounding box coordinates. With a wide variety of aspect ratios and sizes, RPNs are designed to anticipate area recommendations effectively. RPNs use anchor boxes as benchmarks for various sizes and aspect ratios. The strategy, which stays away from listing filters or pictures with different aspect ratios or sizes, may be represented as a pyramid of regression references.

Bounding Box (b-box)

The technique of categorizing items and their locations in a picture is known as "object detection." In most cases, it is accomplished by drawing bounding boxes around the image's object. The box has information about the object as well as coordinates, which show where the object is in the picture.

YOLO

You Only Look Once (YOLO) is a 2016 object detection method. Unlike older approaches, YOLO can recognize many items in an image in real time using a single neural network forward pass. It splits the picture into grid cells and estimates their bounding boxes and class probabilities. This method enables YOLO to be incredibly efficient, making it famous for a variety of applications, such as real-time object recognition in movies and photos.

Darknet-53

The YOLOv3 object detection system is built on a CNN with 53 layers known as Darknet-53. Darknet-19 varies from Darknet-18 in two ways: by utilizing residual connections and by including more layers. In order to build a map with a different approach for comparison, we also employed 3D LIDAR data. This method's 3D LIDAR-based mapping is based on an NDT-based ego-motion estimate. The colors on the map represent the heights of the 3D points. The regions that are mapped by the two approaches are not precisely the same since the sensors have different fields of view [40].

3 | Literature Survey

Abukhader et al. [1] have drawn attention to the necessity for circular and local food supply systems in developing areas as well as the fragility of access to food. Today, AI and indoor VF, which are becoming more common in large cities, are being used to regulate plants remotely. This thesis seeks to increase food production by planning agricultural activities on a vertical farm in order to oversee and manage the farm. One of the most well-known optimization issues is the JSP, which arises when the success of one operation may depend on the outcome of another that is being executed concurrently. In order to resolve the suggested scheduling issue, this research presents a practical approach based on evolutionary algorithms. The allocation of tasks to processors and the order in which each task is performed must be decided in order to solve the issue effectively while minimizing execution time. An optional penalty function allows the approach to search in both feasible and unfeasible regions of the solution space. The results demonstrate how the suggested algorithm works and how it may be used for remote farm monitoring.

Haris et al. [2] comprehend the communication lines, hardware, and software required to provide interaction amongst numerous heterogeneous components. The project CPS/IoT Ecosystems investigates the infrastructure needs for expansive applications. These applications find practical use in various real-world scenarios, such as smart agriculture, buildings, and parking. The infrastructural requirements for a modular indoor VF system are examined in this article. A platform that is service-oriented and has three operational scopes: cloud, fog, and actuator—makes up the recommended prototype.

Bhuvaneswari et al. [3] proposed that combining image processing technologies with machine learning techniques is an efficient strategy for distinguishing between healthy and sick leaves. A variety of disorders cause the chlorophyll in leaves to be damaged, resulting in dark or black marks on the leaf surface. To overcome this, we may use machine learning to do classification, feature extraction, image pre-processing, and segmentation. The Grey Level Co-occurrence Matrix (GLCM) is helpful for feature extraction. We may utilize the collected features to categorize data using a Support Vector Machine (SVM). A CNN surpasses SVM in this case to reach even greater recognition accuracy. This technique, which combines image processing and machine learning, can efficiently discriminate between healthy and sick leaves, allowing for prompt diagnosis and intervention in innovative agricultural applications.

Shrivastava et al. [4] have noted that the effect of farmers and creative agricultural practices has significantly boosted the development of emerging nations. Farming often makes use of outdated, traditional techniques to preserve the crops' yields and quality. Only because of the high quality of the soil and the nourishment applied to the ground did their farming flourish and produce more money. However, the disadvantage is that they had to spend a lot of time on their land in order to acquire their harvests, and the quality of nourishment was not always maintained. More land was also utilized for farming, requiring a significant amount of labor to keep the whole area in good condition. To maximize their time and methods, the majority of nations have shifted to smart farming ideas using IoT platforms. The cutting-edge method for growing more fruits, vegetables, and harvests without soil is hydroponics. The usage of rock wool in agricultural procedures where water pollutants are present periodically will result in large yields and eliminate the necessity for protracted cultivation times. The majority of the nations that practiced intelligent farming with little expense and little labor input used this technique. IoT sensors are used in the hydroponic farming technique to check the state and health of the crops continually. When the system's water or nutrient levels fall, it will effectively replenish everything periodically. A few years ago, hydroponic farming was initially carried out horizontally in specific areas for the constant water flow. However, it is currently used on a vertical surface to save space, and the water only flows when necessary. With this method, crops may be produced more effectively on a small amount of land and with fewer laborers. Vertical hydro farming offers more significant outcomes than earlier conventional approaches; maybe small-scale unit farmers have taken the cost of the complete system into mind. This study describes the development and use of automated vertical hydro farming methods using IoT systems. Big data analytics will be used to examine the data.

Sensors collect data, and machine learning predicts outcomes, resulting in less water and fertilizer use, higher earnings, and more varied income streams for farmers. Additionally, it provides pure organic cuisine. For electricity, we may also utilize solar power panels. This contributes to the environment's ability to live a healthy, pollution-free existence. The hydroponics system will house the sensors. In terms of hardware, more specific information will be provided, and IoT data will be saved in the cloud for ML on IBM Cloud, AWS, Google Cloud, Microsoft Azure, etc. The organic shop, where the organic goods are uploaded together with their prices, will be hosted. The client may check whether or not the product is organic using the QR code they found on their pack, which will have a separate QR code for each area and product. The help desk that they may locate on the site will provide the farmers with all kinds of assistance. The whole system is kept under constant observation, and farmers get their input at regular intervals. In this initiative, cutting-edge technology like machine learning and the Internet of Things (IoT) are utilized to forecast plant growth while simultaneously lowering maintenance costs. When compared to the old-fashioned irrigation techniques, this technology only uses 10% of the water. Additionally, this protects the environment against infections, food poisoning, and pollution [41].

Anubhove et al. [5] provide a summary of strategies for tomato disease diagnosis with the help of machine learning and data analytics. A system that allows a camera-attached device to recognize and diagnose spot disease of tomatoes in real-time is developed using widely accessible technologies. Only spot disease can be identified at this stage. There are two sections to the whole development. The software and algorithm in the first phase were designed to find and classify crop diseases and provide a report for the user. It has been effective in developing the algorithm and GUI that enable users to recognize tomato spot disease. Using the Viola-Jones algorithm and the Haar-like feature extraction method in MATLAB, three hundred seventy-seven images of diseased tomatoes are used to build an XML file or an image training file for identifying tomato diseases. The hardware implementation makes up the second component. The system consists of a simple robot gear that supports the camera and precisely inspects tomatoes for illness with a high success rate. It is simple to add several other illnesses that affect humans, animals, and crops to the system. The system is reliable and has an acceptable false positive rate.

Balasubramaniyan and Navaneethan [42] demonstrated that farmers have difficulties monitoring water, human activity, wildlife, hazardous organisms, cost, and other things. IoT technology will be used to solve these problems. This technique reduces production time, expenses, and farmer health by employing sensors

to monitor the water, healthy animals, and hazardous animals. It also helps farmers avoid risk and sickness. The researchers are looking for a technical solution to enhance the current agricultural services by using IoT. Using different algorithms, this research, which is based on a survey report, aims to assist farmers in increasing crop output of both high and poor grades of harvest. The best quality is chosen using this algorithm, which is also utilized to efficiently manage soil erosion, climate change, and water availability on various sensors. In your last discussion, highlight any research gaps when discussing platforms and trends in agriculture with multiple applications.

Kour et al. [6] agriculture has shifted significantly toward contemporary technology during the last decade. The IoT has transformed the sector by providing real-time farm monitoring and resource optimization via species hybridization. Many governments, scientists, research groups, and academic institutions are working together to investigate the potential advantages for mankind. The IT industry is also working hard to create better solutions by combining IoT with Wireless Sensor Networks (WSN), cloud computing, and big data analytics. This methodology improves real-time operations, data processing, and analysis. The research focuses on adaptive, scalable, and long-lasting techniques that promote interoperability and provide new possibilities. It helps to advance current IoT technology in agriculture by addressing worldwide public and commercial sector efforts, start-ups, and intelligent precision agricultural solutions. The study provides an IoT-based precision agriculture framework that addresses existing circumstances, applications, research potential, constraints, and future problems.

Sangeetha et al. [7] emphasize that the majority of the land is used for industrial and building projects for their comfort. As a consequence, there is less agricultural area available for growing food, which means that there will be insufficient food to feed the growing population. People have been dealing with this issue since the COVID-19 epidemic. The best solution for guaranteeing food security is the development of vertical agriculture. We use a controlled environment in this kind of soilless agriculture to monitor plant growth, record daily EC and pH levels, check for disease, give water with essential nutrients, and measure the concentration of CO2. This research revealed that the consumption of plants varied according to the stage of growth, including germination, vegetative, reproductive, and mature phases. We suggested improved and affordable methods for providing plants with all the necessities in the quantities they needed based on their phases. Two techniques are presented. i. depending on the height of the plant, determine the vegetative stage; ii. using the R-CNN algorithm to determine the stage of reproduction. This assists in letting the farmer know about changes in plant stages at the appropriate time.

Kalantari et al. [8] demonstrated how agriculture and building designs may coexist in a high-rise structure inside a city. Although there isn't much literature on the technology behind VF, it must be integrated into both architectural and agricultural technology. In this research, technology is examined and evaluated as one of the main components of VF using a qualitative approach. The first stage is to determine what VF initiatives are happening now and in the future in Europe, Asia, and America between 2009 and 2016. After that, a thorough examination of the technology and methods used in VF projects was conducted. The 62 sources used to create the research materials ranged from 2007 to 2016. The technologies provided may serve as a roadmap for the creation and design of novel vertical agricultural enterprises in cities. In reality, it may serve as a framework for assessing future architecture and agriculture together. The incorporation of food production in urban areas acts as a link between the city and its inhabitants. This method not only improves food safety but also promotes human well-being, environmental sustainability, and poverty reduction.

According to Despommier [10], 10% of the area where we now cultivate food crops would disappear with every rise in air temperature of 1 degree, according to estimates. Governments are finding it more difficult to maintain systems that provide a steady supply of clean water and food for their inhabitants, as well as other basic services. Other issues already exist in less developed nations that will only worsen as a result of global warming. Typhoid fever, cholera, and a wide range of parasitic disorders are a few examples often seen in regions where around 50% of all farming worldwide uses human feces as fertilizer. The widespread illiteracy and poverty that are a result of these illnesses are primarily to blame. Numerous toddlers and adults are

rendered permanently disabled by geo-helminths alone. Severe ascaris, whipworm, or hookworm infections may impair a child's capacity to study, and the associated diarrheal diseases often result in school absences. The end outcome is poverty, starvation, and illiteracy. Food safety and security concerns now take center stage in the news, even in more developed nations where many of these dangerous illnesses have been either eliminated or are under control. Food recalls caused by bacterial infectious illnesses have cost the US economy billions of dollars in lost revenue over the last five years.

In traditional agriculture, a wide variety of plant diseases like rice blast and wheat rust, as well as insect pests like locusts, are to blame for catastrophic crop losses that are pushing the yields of the majority of vegetable crops and grains ever to lower limits. Flooding and drought-related soil erosion round out the list of climate change-related problems that have already considerably decreased the regions. We may produce our food in a variety of ways. According to the majority of environmental specialists, over the next 50 years, farming as we now know it will shrink as climate change worsens as a consequence of deforestation. This is due to the loss of forests to make way for agricultural land. The upshot of this activity is an out-of-balance carbon cycle, which will only become worse if nothing is done internationally. One way to change this is via controlled environment agriculture. The production of year-round, safer, and more dependable food is assured by greenhouse technologies, which may be situated near metropolitan areas. We can drastically reduce our agricultural impact by cleverly stacking these structures together in an integrated way, allowing us to use the vertical farm concept in any urban area, no matter where it is [10].

Tamana et al. [11] talked about the issue's resolution. In well-known nations, soilless agriculture has been adopted to grow crops using Rockwool. With the help of this ground-breaking method, a tiny plot of land and other resources needed for agriculture may be utilized more productively. The method is known as hydroponics, and it has a significant impact on agriculture, enabling small-scale farmers to see results quickly. This kind of soilless agriculture uses water resources for plant development and then recycles them to reduce water waste. Aquaculture is linked with this method of successfully using natural resources to motivate this notion. The whole system is automated utilizing the IoT architecture, and a centralized controller will be used to operate and monitor everything. The idea of employing fish to develop in a confined space, such as a glass tank or a box of water, is known as aquaculture. This structure may be used in conjunction with clever vertical or horizontal frames and a hydroponic system to minimize labor requirements and enhance resource sustainability in agricultural fields. As a consequence of this research, more plants and fish will be found in the wild, and their economy will develop in a limited amount of area. In order to efficiently manage the specifics of SHAF, the Smart Hydroponic-Aquaculture Farming system is designed using a Big Data analytics framework.

Liu et al. [12] investigate the use of machine learning-based anomaly detection in vertical plant-wall systems in order to increase both intelligence and automation for predictive indoor temperature management. The two types of anomalies studied are contextual anomalies and point abnormalities. The investigation and use of pattern- and prediction-based approaches for detecting indoor climate anomalies. The results show that neural network-based models, namely the Long Short-Term Memory Encoder-Decoder (LSTM-ED) and Autoencoder (AE) models, beat the competition in identifying contextual and joint abnormalities. Because of this, these models can be used in industry to make vertical plant wall systems. Considering the findings, a new method for cleaning data is suggested, and as a piece of actual evidence, a prediction-based method is really being put into practice on the cloud. This study shows how the IoT and machine learning advancements may be fully used to create a research environment that hastens the development of solutions.

Hastie et al. [14] found that statistics is constantly confronted with new problems from both science and business. Initially, the problems were restricted to industrial and agricultural experiments. However, with the introduction of computers and the information age, statistical difficulties have grown in scope and complexity. As data storage, management, and search difficulties became more prevalent, "data mining" emerged as a new field. Similarly, in biology and medicine, the combination of statistical and computational features gave rise to the term "bioinformatics." Many sectors today create massive amounts of data, and statisticians play an

essential role in analyzing relevant patterns and trends, comprehending data implications, and unearthing valuable insights. We refer to this as learning from data. The statistical sciences have undergone a revolution as a result of the difficulties in learning from data. Since computation is so important, it is not unexpected that many of the researchers working on this new advancement are from other disciplines, such as computer science and engineering. We may broadly divide the learning issues into supervised and unsupervised categories. In contrast to supervised learning, which aims to predict the value of an output measure based on a variety of input measurements, unsupervised learning aims to explain correlations and patterns among a group of input measurements without using any result measures.

Gour et al. [15] discuss the studies that have been done on the development of soilless plants and the provision of nutrients under human control to help farmers produce a high yield at a reasonable price. Because of the rapid rate of plant growth, hydroponics was adopted for growing plants. These methods had the drawbacks of requiring a skilled person for maintenance and having a high initial cost. Later, these methods were connected to the IoT to allow for system control over the internet. Compared to a new method called Aeroponics, there was a higher water use. In recent years, machine learning algorithms have been integrated with the hydroponics technique to achieve accurate plant growth based on the nutrients supplied to plants while using slightly less water. In comparison to other methods currently in use, aeroponics uses almost 98% less water. In this paper, existing technologies are discussed with an eye toward crop yield and plant growth, and a practical method for precise plant growth using aeroponics based on machine learning technology by utilizing several input parameters, including airflow, temperature, carbon dioxide, nutrients, humidity, and light intensity, is presented.

Mehra et al. [17] represent the effect on the nation's economy. The use of hydroponics and aeroponics, advanced agricultural methods that allow plants to be grown without soil using nutrient solutions, is on the increase. There have been some studies into using machine learning methods like neural networks and Bayesian networks to manage the development of hydroponic plants. The IOT, which also permits machine-to-machine communication, may be used to automatically and intelligently operate the hydroponic system. The first-ever suggestion to develop a hydroponic system that is based on the IOT is made in this article. The system is sufficiently complex to give the appropriate control action for the hydroponic environment based on the various input parameters that were acquired. As a case study, Raspberry Pi 3, Tensor Flow, and Arduino were used to develop a prototype for tomato plant growth.

Jandl et al. [18] explain that this article establishes the foundation for such methods by offering an adaptable, edge-centric design for self-sufficient vertical farm management that is powered by the IoT. We investigate several deployment methods for it, looking at how employing LoRaWAN as the foundation for device communication may affect design and performance. We demonstrate experimentally that it is viable to enable the administration of vertical farms at scale and low cost, handling monitoring workloads for vertical farms that equate to thousands of IoT devices.

One of the machine learning techniques used in this research is the CNN image processing model, which is capable of identifying and classifying plant illnesses. In this study, a method for AI-based lettuce illness detection is suggested. An AI model has been created to recognize distinct lettuce illnesses. ResNet50 and ImageNet were used to build the model using TensorFlow. To make up for the small training dataset, a variety of overfitting prevention techniques are also used on the model, and the study's findings are described. It will point people in the direction of increasing their level of comprehension of the importance and need of using various machine learning techniques and alternatives to traditional agriculture in order to achieve sustainability [19].

A prototype of an integrated system for maintaining a regulated atmosphere perfect for VF is shown. In-depth research is done on the ideal artificial lighting requirements for the various development phases of tomato and chili plants, and a technique based on the CNN model is also created for the early identification and categorization of leaf disease. To create an artificial environment that assures enough artificial light, moisture, and minerals, various sensors and actuators were implanted into the plant beds. These devices were

then connected to a network through a cloud-based remote server. Various plant development phases were observed using a CMOS image sensor module. Compared to natural sunlight, artificial light conditions require much less time and energy for tomato and chili plant germination, growth, and blooming. At the end of the fifth epoch, the CNN model had a validation accuracy of 67.2% and a training accuracy of 84.8%. Novelty: In north-eastern India, tomato and chili plants are grown at different times, and their light levels are changed to find the best artificial light. In northeastern India, tomato and chili plants are grown in different phases, and the need for the best artificial light is explored by subjecting them to various light intensities. The investigation was carried out in the summer (May–June) when eastern India saw 130–190 hours of average solar exposure. Utilizing deep learning models, the recorded photos and data were used to track the health of the crops and detect infections. It is shown how to identify different types of leaf disease using a CNN model [20].

Jaiswal et al. [22] say that automation has replaced human labor in practically all sectors of endeavor thanks to the fast advancement of technology. Over time, the evolution of human-computer interaction has quickened. Technology has advanced considerably since the invention of the greenhouse. It's crucial always to keep an eye on the ideal plant development conditions if you want 100% yields. Using Raspberry Pi and Arduino, this study monitors, regulates, and coordinates several aspects that affect crop production, such as light intensity, CO2 levels, humidity, temperature, and soil moisture. The IoT has made it feasible to collect data from the Smart Greenhouse in real time and visualize it on the Thing Speak platform. A more advanced and diversified version of the current models in use is being developed; this article suggests a completely automated greenhouse integrated with hydroponics and VF, as well as extraordinary security measures and monitoring.

Masuzawa et al. [16] addressed the use of mobile robot technology to help with harvest in the greenhouse horticulture industry. Despite the fact that there are a number of fruit and vegetable harvest assistance robots, their autonomous navigation typically necessitates the alteration of a greenhouse. Therefore, our objective is to develop a robotic arm that can control and aid in cropping activities in normal greenhouses, especially flower harvesting. Based on research into the technologies necessary for harvest aid robots, they created a mobile robot prototype that is capable of 3D mapping and person-following. In a real greenhouse, we carried out preliminary research and assessed the built robot system.

To monitor and adjust critical agricultural factors such as temperature, soil moisture, CO2, and light, a remote sensing and control system for greenhouse agriculture was created. To enhance crop development, the system changes the greenhouse's windows and doors periodically throughout the year depending on soil moisture levels. The key goals are to boost product output and to make organic agricultural methods more accessible. The findings show that CO2 levels, soil moisture, temperature, and illumination in the greenhouse may be successfully controlled remotely, leading to enhanced agricultural outcomes [23].

Bakar et al. [24] discuss how to boost crop quality and quantity while improving crop disease management in indoor agriculture, which primarily uses vertical structures. This study aims to develop an image-processing-based crop disease detection system for VF. One computer vision technique used to recognize and process an item in a picture is image processing. Consequently, the plant sickness is detected using the image processing approach. The disease detection method includes the steps of feature extraction, sickness categorization, image segmentation, image acquisition, and image pre-processing. The first input photographs were from VF and were taken using a digital camera. The diseased region of the leaves was then predicted using k-mean clustering during the picture segmentation process. The color-based segmentation method K-mean clustering is applied to categorize the polluted region into categories that apply to it. Based on its texture and color, the illness spot's characteristic was retrieved. The Multi-Support Vector Machine (MultiSVM) approach was used to categorize features and then classify the illness. An experimental investigation was performed on four Choy Sum plant samples to identify the sickness—the proportion of the plant that was infected and its accuracy. The maximum accuracy for downy mildew disease was shown by plant number 4

(98.3871%, area of infection: 11.0154%), whereas the highest accuracy for healthy leaves was shown by plant number 1 (98.3871%). Finally, this project is able to construct the GUI for the whole illness detection system.

Calicioglu et al. [43] studied the interconnections between the solutions put forth to solve the difficulties using social network analysis methods, concentrating on the fundamental causes and patterns of the challenges facing the agricultural and food systems. It was discovered that the trend network is most influenced by climate change and that many other problems would be partially resolved if trends leading to extreme poverty were to be reversed. Access to and use of food would benefit from increased food security. The explicit depiction of the qualitative linkages between them will aid the decision-maker in prioritizing the issues and insights. To successfully apply the actions proposed to address the problems, a more in-depth quantitative study is required.

Viljanen et al. [25] emphasized that in Northern Europe, silage is a crucial feed for ruminant meat and milk production. Although more complex uses of this data are being developed, advanced drone-based remote sensing technologies were used at different phases of silage production. The goal was to create and test a novel machine-learning algorithm for predicting grass sward biomass and canopy height using multispectral photogrammetric sensor data. Different harvest dates and nitrogen fertilization amounts were applied to induce variety in the crop stand under investigation, which consisted of a mix of meadow fescue and timothy. The researchers used Vegetation Indices (VI) and near-infrared intensity values from orthophoto mosaics to extract numerous properties utilizing red, green, and blue data using an ultra-high-resolution photogrammetric Canopy Height Model (CHM). Combining CHM and VI data, as well as all three feature classes, yielded the best estimate results. Multiple Linear Regression (MLR) and the Random Forest estimator (RF) both produced exact findings. The Fresh Yield (FY) and Dry Matter Yield (DMY) computations yielded good Pearson Correlation Coefficients (PCC) of 0.98 and 0.34 t/ha (12.70%), respectively, and Root Mean Square Errors (RMSEs) of 0.98 and 1.22 t/ha (11.05%). The machine learning technology beat standard linear regressions and demonstrated sensitivity to diverse growth stages and biomass volumes. The research proved that the suggested multispectral photogrammetric approach can estimate biomass correctly in grassland, making it a cost-effective tool for beneficial agricultural applications.

The significant components of automated and environmentally friendly VF methods that combine the IoT idea for smart living are examined in this study. The research examines 30 peer-reviewed studies published between 2004 and 2018, including actual VF deployments. The crops or plants that are employed in VF. VF topological size. Sensing data gathered for monitoring purposes. Hardware used, such as sensors and actuators. VF system power sources. Data collection frequency or pace. Data storage methods used. The utilization of communication technologies. Data analysis techniques and algorithms used. Other techniques used in the VF method. Countries that have used IoT to implement VF [26].

According to the data, the majority of research (40%) used VF systems with 6-20 levels, with lettuce being the most typically cultivated crop (28.6%). Solar power was used in just 11.1% of VF systems, while batteries and AC electricity were the primary power sources for sensors (44.4% each). Light intensity, room temperature, soil nutrients, and moisture levels were the most widely utilized IoT sensors.

Data from these sensors was gathered every 1 to 3 minutes (42.8%) and sent by Zigbee, Wi-Fi, and VGs (42.8%). Data storage included remote data management solutions, cloud storage, and server databases (all of which contributed 25%). Following data gathering, the majority of research (50%) employed threshold-based algorithms to make decisions, with hydroponic (38%) and soil-based (42%) plant production approaches being the most common.

VF also makes use of solar power (20%), reused and recycled water (30%), and regulated indoor settings without sunshine or soil (20%). Vertical agricultural automation using IoT is the key emphasis in the United States (41.2%) and China (23.5%).

Foreign VG patents were also investigated in order to acquire insight into autonomous control or IoT applications in vertical gardens. The study also looked at the possible effects of vertical cultivation walls on people's well-being [26].

The accuracy of several techniques for assessing Herbage Mass (HM) on timothy-meadow fescue pastures was evaluated using three distinct instruments: a disc meter, a sward stick, and a capacitance meter. The research included 714 paired observations, each with cut HM measurements (B1 cm). Linear models were used to explain the variation in HM adequately. Individual comparisons were made for each occurrence since DAY had a considerable effect on the parameter estimations for the sward stick and capacitance meter [27].

The residual standard deviations ranged from 132 to 1151 kg/ha, while the r2 values ranged from 0 to 0.91. The capacitance meter had the lowest accuracy among the equipment, whereas the disc meter and sward stick supplied the most exact HM estimations in kg/ha. The benefit of the disc meter was the constancy of model parameters on a daily basis, but the sward stick readings could be employed immediately in practical applications.

When exact HM estimations are needed for small-scale research, none of the strategies were sufficiently dependable. All techniques, on the other hand, demonstrated utility in more extensive regions or circumstances when HM estimates can tolerate higher mistakes [27].

After reviewing, the research aims to determine the needs and use cases for new plant manufacturing. These plant manufacturers get a design with a proven operational proof of concept that is backed by both commercial and academic standards. Furthermore, there is a desire for a comprehensive co-design process that extends beyond the disciplines of communication, computers, and AI. This technique seeks to assure thorough solution design while also accelerating the engineering implementation of factories, plants, and other industries with comparable needs [28].

Singh et al. [29] developed a new era of agricultural technology known as VF. In the future, it could be able to provide all of the food needs. Looking at the present agricultural trend, VF can include and assist all areas of agriculture in several dimensions. Given the shrinking agricultural regions, it is an innovative method of agriculture to fulfill the need for food. The productivity and quality parameters will improve VF by using cutting-edge technology like AI, ML, and IoT. This chapter demonstrates how modern technology is used in farming to improve farmer productivity and a nation's economy. Farming monitoring is a dependable and efficient approach to managing daily operations on agricultural land [30].

Chen et al. [30] explore the use of AI for tasks including categorization, detection, and forecasting in soil management and MVF. Three widely used categories of AI and machine learning approaches—SVM, Decision Tree, and Neural Network-based models—were discussed. Urban farming's prospects for the future are also examined. Challenges in soil and crop management include rising demands to increase food safety and provide for a rising population. By merging information and communication technology into agricultural practices, smart farming helps to address these concerns. A highly promising idea in smart agriculture, the Multiponics Vertical Farming (MVF) system reduces the need for space, transportation expenses, and delivery times. Advanced technology can handle complex systems and chaotic data to increase the precision and effectiveness of computing and modeling. AI offers quick assessment and assists in creating efficient solutions for dynamic and complicated challenges.

Iris biometric identification is the method of automatically identifying people based on their iris characteristics. The iris stroma's distinct appearance makes it a valuable indication for biometric identification. The subtle textural distinctions of an individual's iris pattern may be efficiently recorded and retained by projecting an individual's iris pattern onto Gabor wavelets and translating the resultant phasor response into a binary code. Daugman's approach has shown to be a reliable feature descriptor with meager false acceptance rates and minimum processing needs. Because of recent advances in machine learning, CNNs are capable of extracting complicated visual characteristics. We evaluate how successfully state-of-the-art pre-trained CNNs identify irises based on their performance in several computer vision tasks, including the ImageNet Large

Scale Visual Recognition Challenge. Our research uses two iris datasets, ND-CrossSensor-2013 and CASIA-Iris-Thousand, to show how commercial CNN features can successfully model iris pictures, extract discriminative visual features, and produce promising recognition results. These features, which were created for general object categorization, are now used for iris identification. We do, however, highlight the obstacles and prospective research directions in applying deep learning methods for this purpose [31].

Hernandez-Diaz et al. [32] submitted to the challenge of periocular recognition within the framework of the ILSVR Challenge. They have proven to be very successful for a range of additional computer vision applications in addition to the recognition and categorization activities for which they were designed. The tests make use of a database of digital camera-taken images of the periocular region. We demonstrate that despite being taught to categorize generic items, these pre-built CNN features can successfully identify people based on periocular pictures. They exhibit an EER decrease of up to 40% when compared to reference periocular features, and the combination of CNN and conventional features results in further improvements.

Because of the critical necessity for exact apple recognition and obstruction-free access throughout the collecting process, apples are well-suited for automated selection. Modern orchards with vertical fruiting wall plants have greatly facilitated the collection of apples. However, the presence of non-target trees and fruit from surrounding rows in field pictures is problematic, resulting in complicated backdrops. To solve this problem, an outdoor computer vision system using a modest Kinect V2 sensor was built to improve Apple recognition performance by removing background objects based on depth characteristics. The system took 800 photographs in a commercial fruiting-wall Scifresh apple orchard with extensive leaf cover, utilizing artificial light for both day and night shots. The sensor was placed 0.5 meters from the tree tops, and a 1.2 m depth threshold was used to eliminate background interference. Two quicker R-CNN-based architectures, ZFNet and VGG16, were used to identify the Foreground-RGB and Original-RGB pictures. With a value of 0.893, the Foreground-RGB pictures using VGG16 earned the best Average Precision (AP). A 1920 by 1080 picture took 0.181 seconds to analyze on average. In terms of AP values, ZFNet and VGG16 with Foreground-RGB photos surpassed Original-RGB shots. The findings showed that adding a depth filter to remove background trees increased fruit recognition accuracy by 2.5% while not affecting processing speed across the two picture datasets. The proposed approach and results have the potential to be used in robotic harvesting on apple orchards with fruiting walls, improving efficiency and accuracy in apple selection operations [21].

Edge and noise information were discovered utilizing the techniques of noise detection, fuzzy morphological gradient filtering, and pre-and post-edge identification using fuzzy contrast enhancement. The Convolution Neural Network's ResNet-164 design allows for automatic feature extraction. The generated feature vectors are classified with the aid of ANFIS deep learning. The error rate for the top-1 decreased from 21.43% to 18.8%. The top-5 mistake rate drops to 2.68%. The suggested approach yields excellent accuracy rates at little computational expense. The accuracy is 98.24% on a typical dataset, and the recognition rate is 99.18%. When compared to the present approaches, the recommended work is superior in every manner. Results from trials on the cutting-edge datasets CMU-PIE, Feret, JAFFE, Yale-B, FACES 94, and others exceed those from traditional approaches [34].

The process of transforming photographs of handwritten, typewritten, or typed text into a format understood by computers is known as optical character recognition. Optical Character Recognition may be used for editing, indexing, searching, and reducing storage space. This is accomplished by first scanning the text image character by character, processing the scanned image, and then transforming the character image into character codes, like ASCII. The Optical Character Recognition technology is used to convert text contained in a picture into text format. Pre-processing, character recognition, character segmentation, and data display are the three main components of the OCR technique. Convolution neural networks, a deep learning method, are used to recognize characters. In this paper, CNN's architecture, layers, and implementation are discussed. We use a Telugu character data set with a maximum of 1600 characters to assess the CNN (VGG-16) model's accuracy [36].

Noorani et al. [37] made the garbage management technique simpler. CNNs may be used to identify and categorize garbage. This article uses CNNs like the Berkeley Reference model, AlexNet, and GoogleNet to recognize waste things inside garbage piles.

The proposed technique applies deep learning to image processing by using the CNN model., to categorize the different kinds of pests and then recommend the most appropriate treatment based on the type of insect. Using this technique, the user will find it more straightforward to grasp information regarding pests and pesticides that should be utilized. Convolutional networks and supervised techniques are trained to identify four different pest species and suggest the most appropriate insecticides using a public dataset of 1265 photos of bugs [38].

Anand et al. [39] recommend a LiDAR SLAM system based on semantic segmentation. The uncertainty is clearly described by recommended probability models, which are built using data-driven approaches. The study highlights semantic registration, which uses provided probability models and semantic data to determine the transformation connection between successive point clouds. When numerous scans suggest various classes owing to ambiguity, the semantic class of the points is also determined using the proposed probability models. The KITTI dataset and outdoor settings are used to verify and assess the proposed system. The results of the experiment show that the recommended semantic mapping framework minimizes mapping, poses flaws, and eliminates the ambiguity of the semantic content of the acquired semantic map.

The idea of building and executing vertical farms has been put out to solve the sustainability problem and to satisfy the rising food demand. VF refers to the practice of producing animals and plants on surfaces that are tilted vertically. In order to evaluate the main possibilities and issues of the practice, this study examines how VF may affect future food production in cities using the notion of sustainability. In this research, 60 documents from linked published articles from pertinent publications and scholarly internet sources are critically reviewed. VF may raise the food supply while sustaining high-quality standards and protection, and it promotes sustainable urban farming. The well-known benefits of producing food in urban areas may be advantageous for the environment, society, and economy. Additionally, vertical farms may provide methods for enhancing global food security [44].

The purpose of this project is to use an autonomous IoT system to provide a regulated environment for VF. The major goal is to create a system that maintains soil moisture and monitors water content through an internet browser on a variety of portable devices such as laptops and smartphones. A soil humidity sensor is used for this purpose to continually monitor the moisture level in the soil of the vertical farm, ensuring the plants get appropriate water. The system is developed on the Arduino platform, which receives signals when the soil moisture level falls below a certain threshold. The data is saved in the Arduino IDE software and sent to the web browser through Ethernet, which is linked to the internet router. Users may monitor their plants, check the soil moisture level, and even activate the water valve to release water as needed via a web browser. This development in VF monitoring has proved to be quite advantageous since it enables the plant's growth to be watched remotely, eliminating the need for the operator always to be on-site. VF becomes more efficient and controllable with an IoT-based technology, assuring ideal conditions for plant development and output [45].

Using image processing and machine learning approaches, this study proposes a viable method for distinguishing between healthy and sick leaves. Different disorders may cause chlorophyll degradation in leaves, resulting in dark or black marks on the leaf surface. Machine learning approaches for feature extraction, classification, image pre-processing, and segmentation are used to detect these difficulties. For feature extraction, a grey-level co-occurrence matrix is employed, and the SVM is one of the machine learning methods used for classification. In contrast, the CNN strategy outperforms the SVM approach in terms of recognition accuracy. This research shows how machine learning and image processing may be used to recognize and categorize healthy and sick leaves, offering valuable insights for plant health monitoring and agricultural applications [46].

Farooq et al. [47] are seen as a potential alternative approach to resolving the food issue caused by rapid population increase, climate change, and environmental degradation. Even in harsh climate zones, this technology may maintain off-season crops inside the enclosed space. In a greenhouse, it is essential to accurately and safely manage and control the crop properties. The growth of the IoT has allowed for the establishment of intelligent methods for automating greenhouse farming practices, including plant monitoring, indoor environment management, and irrigation control. The study displays a hierarchy of the essential components of IoT-based greenhouse farming practices. There has been much discussion on the IoT based greenhouse classifications; network technologies are IoT protocols, sensors, cloud/edge computing and data analytics, and greenhouse farming techniques.

Additionally, a thorough explanation of IoT technologies and mobile-based greenhouse apps for managing the greenhouse farm has been provided. Additionally, to standardize IoT-based greenhouse farming, success tales from some agricultural countries and data analysis have been given. Finally, cutting-edge future research paths have been discussed together with the outstanding questions and research problems linked to IoT-enabled greenhouse farming [47].

In a tomato greenhouse, a simple, smart agriculture system with low resource costs was designed and used. For agricultural environment monitoring and management, the system's real-time information capabilities are made up of commercially available, reasonably priced WSN sensors and a designed online database (web DB). Based on an agro-climatic metric called growing degree day, the crop microclimate environment was observed (GDD). GDD was used to estimate the microclimate spatiotemporal distributions, which revealed distinct microclimate fluctuations within the greenhouse. The online database created for tomato farms had incorporated crop calendars. We used our smart agriculture technology to conclude improved crop management and crop production. The cost-effectiveness of the system is based on its applicability in terms of original cost, ongoing expenses, and the dependability of WSN data. As a result, it might be used for the precise planning of crop output and the decision-making of cultivation operations [48].

Lohitha et al. [49] describe the hydroponics technique of growing plants without soil using a fertilizer solution. The nutrients used in hydroponics may originate from a variety of sources, including artificial nutrient solutions and duck dung. The primary benefit of hydroponic farming is the reduction in water use. In contrast to horticulture crops, the strategy takes into account several species that fit certain expectations and are impacted by complicated environmental factors. Consideration must be given to the variations in temperature, light, and humidity. Through a mobile device, this strategy was utilized to notify farmers of the times for ripping, fertilizer spraying, pesticide application, and watering. The planned work will cut the cost of gardening and the quantity of soil and water needed to sustain it. The suggested strategy may concentrate on giving the plant enough water, nutrients, and light at all phases while also being highly beneficial in keeping a garden with fewer pesticides. LABVIEW software has been used to run every simulation.

Temperature, water temperature, moisture, pH, and nutrient content were studied as the foundation for the construction of the controlling and monitoring system since these factors are crucial for plant development and growth. The results of this study show how to choose sensors using program-defined comparison and contrast functions. Microcontrollers and free software were used to process and program the data that were obtained (Arduino and Blynk). To be more precise, electricity and temperature control for the whole system were provided by solar Photovoltaic (PV) and geothermal systems. According to the findings, it was possible to monitor and manage the environment and necessary nutrients for a plant via the design and selection of suitable sensors and equipment. The system as a whole was powered up, enabling the device operations, thanks to the incorporation of solar PV as well. The ground heat exchanger system was also included, which helped to lower the temperature to an average of 5oC. Additionally, the system could show the plant's data and alert the owner to any systemic issues. Further enhancement of the system's structural design and assembly may be advised [50].

Henningsson et al. [51] examine earlier studies and experiments to look at the potential for developing an automated greenhouse as well as the potential benefits that such a greenhouse might offer, such as

significantly more efficient water use, better space utilization, and the ability to feed a larger population without increasing transportation costs. Additionally, this study investigates already tried and proven techniques: Many of the earlier approaches relied on object identification and subsequent leaf counting to address issues related to plant phenotyping rather than attempting to build an automated greenhouse. These techniques served as a significant source of inspiration for the study but had little effect on the result. It is a report in which I have made an effort to develop a strategy for how to begin, how to think when starting, and how to progress with a project in this setting. I've concluded that while the technology was not yet capable of doing this work at the time this report was produced, it has now developed to the point where it is feasible. Some people have found success using it in this situation. I also concluded that cameras and object detection may perhaps be a nice-to-have rather than a necessary component of an automated greenhouse.

The idea of running a cyber-physical farm emphasizes the use of communication and information technology in agriculture. The incorporation of developing technologies such as IoT and cloud computing is predicted to transform the usage of robots and AI in agriculture. This transition is sometimes described as "big data," in which huge volumes of heterogeneous data are acquired, processed, and used for agricultural decision-making. This study digs into the most recent big data applications in smart agriculture, discussing the underlying socioeconomic concerns that must be addressed. A systematic strategy is presented, along with an analytical model that might guide future studies in this field. According to the report, big data applications in contemporary agriculture influence the whole food supply chain, reaching beyond primary production. Companies are transforming their operations by implementing novel marketing tactics, making real-time operational choices, and gaining predictive insights into agricultural practices using big data. Because of the deployment of big data technology, experts foresee substantial changes in the roles and power dynamics among players in the food supply chain. Interactions between large IT businesses, Venture Capitalists (VCs), and tiny start-ups characterize the landscape [52].

Furthermore, public organizations contribute to progress by sharing open data while protecting individual privacy. Two possible future scenarios for smart farming are outlined. One approach is open, collaborative systems in which farmers and other stakeholders have the freedom to choose technology and food production partners. Closed, proprietary systems in which farmers are part of highly integrated food supply networks are another option. The path of this growth is determined by data and application infrastructures, as well as their institutional integration. From a socioeconomic standpoint, the authors advocate focusing research on organizational governance challenges and suitable commercial models for information sharing across distinct supply chain settings [52].

This research focuses on the use of AI and computer vision algorithms to discover patterns in images, as well as their potential use in precision agriculture. The study examines the five most extensively produced crops in the world: rice, wheat, maize, barley, and soybeans. Over the last five years, twenty-five research studies have been examined to address concerns relating to phenotyping, grain quality, and disease detection in these crops. The comprehensive study's findings suggest tremendous prospects in the area of smart farming. Deep Belief Networks and other advanced AI technologies and graphics processing units offer promise in establishing trustworthy computer vision algorithms for agricultural applications. These strategies have the potential to improve precision agricultural operations by giving vital information and assisting in crop management and monitoring. Finally, this study emphasizes the significance of using cutting-edge AI and computer vision technologies to solve agricultural difficulties and enhance crop output, eventually contributing to the evolution of intelligent farming methods [53].

Liu et al. [54] examine the contemporary condition of industrial agriculture, as well as the ramifications of industrialized agri-food supply networks, agricultural production methods, and production patterns. Furthermore, the study focuses on five cutting-edge technologies in the context of Agriculture 4.0: IoT, blockchain, robotics, AI, and big data analytics. The critical research problems and possible uses of these developing technologies in agriculture are examined in depth. The study's goal is to present readers, particularly industry practitioners, with fresh research prospects by emphasizing the relevance of these

technical breakthroughs. Agricultural 4.0 has the potential to change the farm industry by enhancing efficiency, sustainability, and decision-making processes via the combination of IoT, blockchain, robotics, AI, and big data analytics. As these technologies advance, their use in agriculture may bring about dramatic changes and open up new options for industrial innovation.

Urban VF is a novel concept that uses technology and automation to optimize land usage and increase future food supply. This idea includes growing crops in urban, indoor, climate-controlled high-rise buildings, with the goal of significantly growing output while lowering environmental effects. VF can provide a clean and environmentally friendly food supply, improved biosecurity, resilience to pests and droughts, and decreased dependency on fossil fuels and transportation. This article objectively analyses the pertinent problems related to urban VF, as well as its possible advantages and downsides. Policymakers are advised to evaluate the possible ramifications and fund more economic research to better understand the overall effect and viability of this strategy in molding the future of agriculture [55].

Ayaz et al. [56] show both the potential of sensing devices and the IOT in agriculture, along with the challenges that will come with new technologies being integrated with existing agricultural practices. The IoT hardware and communication techniques linked to sensing devices used in smart agriculture are thoroughly analyzed. The article explains how this technology helps farmers with all aspects of crop-related activities. This article also considers the use of artificial aerial vehicles for crop production enhancement and other valuable uses, such as agricultural surveillance. Where possible, modern IoT-based agricultural technologies and architectures are also highlighted. On the basis of this in-depth research, we conclude by highlighting potential research issues as well as current and projected IoT in agricultural developments.

Jayasekara et al. [57] use controlled environment agriculture to enhance and increase plant development. Currently, Sri Lanka uses this sort of agricultural idea. This study report suggests a robot that can be utilized within greenhouses and has a particular navigation system and harvesting mechanism. In greenhouses used for modern agriculture, where lettuce must be meticulously chosen to ensure supermarket quality, the proposed technique may be utilized to produce lettuce. When the approach mentioned earlier is used to diagnose plant ailments, a significant amount of time may be secured, and much less effort is needed.

Siregar et al. [58] make an effort to use restricted access to land, especially in densely populated areas. Urban agriculture, which has limited access to both water and land, is among the issues that vertical agriculture may help to address. One of the literary techniques used in this study inquiry is the PRISMA tool. It is a helpful technique for determining the validity of articles for use in a literature review or systematic review as part of this research. Reviewing an overview of the scientific literature on VF that has been published in the past six years is one of the objectives of this research. The IoT, deep learning, machine learning, and other forms of AI have all been used to the utmost degree to enable precision agriculture. This is particularly true of its use in VF. The findings of this research explore potential future directions and all of the issues and technical developments in the field of vertical agriculture.

By 2050, it is expected that between 70% and 90% of people on Earth will live in cities. Due to the triple effect of desertification, climate change, and urbanization, vertical farms are now a feasible alternative. While VF is assisting in the solution to this issue, computers, and vertical agriculture are working together to solve this problem; year-round production of food crops is now possible despite changing climatic circumstances because of exponentially enhanced efficiency and the creation of comfortable, controllable surroundings. We go a step further in this work to examine how computer vision may support this procedure. This study examines how computer vision and machine learning techniques may be used with the IoT to manage and foster the growth of vertical farms and how computer vision can monitor intrinsic elements. Till now, the farm's extrinsic elements have been monitored by IoT in order to gather pertinent data. The flaw in such an approach is that it simply keeps an eye on external things [59].

López-Cruz et al. [60] describe essential developments in models that dynamically represent the greenhouse climate to date, including their organization, analysis, parameter estimations, and model performance. The core model's structural elements are described using the system state-space method. The physical processes

that are included in the greenhouse effect's dynamic equations are highlighted. The three kinds of equations used are differential equations, difference equations, and transfer functions. Mechanistic and black-box models include the two categories of dynamic greenhouse climate models. The study's main finding is that ordinary differential equations are often utilized in greenhouse climate models, either to get additional knowledge about the system or to control and improve it. ARX, or difference equations, were seldom used in models. Understanding the greenhouse system requires more complicated greenhouse climate models, which have also been constructed, but models with fewer states are more effective for optimization and control reasons. The bulk of dynamic models of the greenhouse environment are built on the basis of the first law of thermodynamics, which combines mass conservation with energy/enthalpy analysis. The creation of greenhouse climate models also lacks sensitivity analysis and uncertainty. In actuality, no uncertainty analysis was performed on any of the improved models. Only a preliminary sensitivity study, a few formal local sensitivity analyses, and no global sensitivity analyses have been published for specific greenhouse environment models.

Cambra et al. [61] demonstrate that in hydroponic farming, a pH sensor with auto-calibration can find and fix pH irregularities in the fertilizer solution used. In our solution, an auto-calibrated pH sensor is linked to a wireless node. A pH probe, many micropumps that alternate between various liquid solutions to keep the sensor calibrated, and water samples taken from channels holding nutritional solutions comprise the system. The WSN controls our greenhouse and has many nodes. The sensors periodically check each hydroponic support's pH level, and the findings are sent to a database. The database stores and examines the information to notify farmers of the required activities. The data may then be viewed online via a user-friendly graphical interface on a desktop computer, a mobile device, or both. This article also demonstrates the design and test bench of the wireless network as well as the auto-calibrated pH sensor to guarantee correct operation. [59] proposes a monitoring system for the environmental factors affecting greenhouse-based rose flower production. Its major goal is to control agricultural production time while enhancing crop quality. A system made up of autonomous quadruple-wheeled vehicles connected by a WSN has been created to do this. This approach assists in making decisions about how to manage a greenhouse's state of the environment so that roses may grow in the best possible settings. A data analysis approach was used to build an in-situ intelligent system that is capable of making informed decisions regarding the cultivation process. This approach includes the processes of supervised classification, prototype selection, and data balancing. The recommended approach significantly reduces the quantity of data in the training set produced by the WSN while still achieving excellent classification results in real-world situations (90 and 97.5%, respectively). The use of the global positioning system to provide correct route planning and choice for the autonomous vehicle is a noteworthy result.

Angelopoulos et al. [62] introduce that the strawberry's distinctive scent, vivid red color, juicy texture, and sweetness are greatly admired. When it comes to the final product's quality, they are, nonetheless, among the most delicate fruits. Current commercial trends indicate that there are quadruple-wheel growing numbers of farmers who sell their products directly to customers and who are more engaged in utilizing intelligent services for the ongoing control of the factors that affect the quality of the completed product. Smart irrigation methods based on the cloud have become more prevalent in recent years. But because of network traffic, security risks, and legal concerns associated with sharing crop data with parties outside the network's edge, strawberry farmers and data owners are compelled to rely on global clouds and risk losing control over their data because it is typically transferred to third-party data center proposed a three-step systematic approach to create, deploy, and validate a method for intelligent strawberry watering in greenhouses that keeps the pertinent data at the network's edge. We first develop a small-scale smart irrigation prototype solution using commercially available hardware and software, provide a benchmark network design for strawberry greenhouses that focuses on smart watering and data dissemination at the edge, and accept the provided reference design and implement it in the strawberry greenhouses with a full-scale system. This method enables us to gain insightful information for larger-scale deployments. We show that our design significantly

outperforms the present method when it comes to moisture fluctuation in the soil and water usage, and we conclude by analyzing the different benefits and drawbacks of our approach in the agricultural industry.

4 | Conclusion

After studying and examining around 35-40 research papers, we found that there is a huge difference between traditional farming and VF, though the methods have similarities. Obviously, the maintenance of the whole agricultural system is no joke. A proper algorithm and technique, as well as proper research, have to be done. Considering the landlord problem, population, and quality analysis of farming, the study shows that proper execution of the planning will enhance the agriculture sector. One study sought to create a powerful genetic algorithm to solve the job-shop scheduling issue, and the results have provided the researchers with the information they needed [1]. Another research describes how new technology, such as pest-free plant growth, insulation techniques, and aeroponic systems, have not only revolutionized the greenhouse business but also shown how they may be used on our balconies or flats [44]. It has been reviewed that the proposed system focuses on the small land-load areas where more commercial buildings and less space for farming are available, but in less space, we can also do farming vertically [3]. The unique method of cultivation with big data analytics entails reusing water consumption while also more efficiently reducing the price of agriculture and land for implementing smart farms. Small-scale farmers will be able to utilize it economically, and it will also be used inside the house. Using indoor VF, women gain knowledge about agriculture farming and gain practical knowledge [4]. Many further studies have reviewed the development of an algorithm that has enhanced the practical technique because it can efficiently detect human body parts as well as objects [5]. Obtaining only theoretical knowledge will not give the difference between traditional farming and VF. Still, we have to look over the technologies, applications, images, algorithms, etc., with the help of IOT, ML, DL, etc., without not following the agriculture trend, we cannot realize that agriculture is the backbone of the farmers. According to a respectable study work that examined observations of the vegetative stage and reproductive stage, we can identify plant height during the vegetative stage and correct the blooming stage by utilizing the R-CNN detection algorithm [7]. Now, after studying so many peer-reviewed papers, we have at least acquired the in-depth knowledge implementing machine learning, or if we dig the ground more efficiently and gather knowledge about anomalous detection, it has been estimated a stable pattern for anomaly detection on the univariate indoor environment. Since it is somewhat tough to estimate the pattern for complicated environments so that's why with the help of abnormal detection, multivariate sensor data analysis finds the hidden pattern and reduces the complexity [12]. Now, after switching from traditional to VF, some relevant comparisons have expanded, revealing that the average requirement for light is approximately 1.2 to 1.6 times higher with a 200-watt bulb [20]. Today, all this research is taking place because of the idea that a great population is going to be the reason for the scarcity of food production in the world. The limitation of the resource is the major problem, but it has been concluded that the over-fitting prevention method already has the solution to the problem [20]. As we know, most freshwater is utilized in the agriculture sector, and water utilization should be increased. That's why automated watering sensors have been detected, and the system has been enhanced using an alert warning system [45]. Now, after discussing all methods and techniques, the question arises of whether we are studying or researching VF, but what is the connectivity with the technology? So, to answer this question, we came across the concept of a CPS/IoT ecosystem. Reducing waste and reutilizing energy has been a way of integrating IoT in production-as-a-service, which means proper execution in VF. If the crops and plants capture improper energy consumption, then the cost-effectiveness will be increased [2]. It has already been accepted that in the case of traditional farming, due to improper use of chemical fertilizer, many plants and crops got damaged, and that's why it cannot be let the way to be going like this in a vertical plantation. A GLCM is used to detect the leaf disease component by retrieving several attributes to assess whether the same things are occurring or not. Different machine-learning techniques were applied, and the result was that CNN had given 97.71% accuracy [46]. Now, apart from lettuce and tomato, one of the researchers has researched silage production. In a prediction comparison between the Random Forest Estimator and MLR, the combination of 3D, RGB, and VI properties was recorded. Analysis of the results revealed that RF is superior to MLR. Random Forest is one such machine learning approach that

offers superior results thanks to its orthomosaics and ultra-high resolution CHM [25]. Now, whether traditional farming or VF, storing big data and maintaining the record are big challenges. In order to manage the whole storage and connectivity system, an IoT greenhouse network structure focused on cloud computing and big data analysis is created [47]. As we compare traditional and VF studies, we have to keep in mind that VF is the advanced technology of smart farming. The results of the case study of a tomato plantation show how GDD data may be used to determine the spatiotemporal fluctuations in a greenhouse, and they imply that the application might be applied to additional tomato greenhouses [48]. Now, the research will not be successful until and unless its proper utilization benefits the users or farmers. That's why a prototype mobile robot with person-handling capabilities was developed with the help of YOLO so that farmers can monitor their fields from anywhere at any time [16]. Next, we went through the research papers, realized the abundance of smart agriculture farming, and thought about something creative. We cannot clean up or displace the smart agriculture system totally from the country, but it has become necessary to switch to VF. To develop the economic state of any country, both traditional and VF, the food security index will gradually fall and may invite disaster in its own house.

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